National Defence / Défense nationale

DEVELOPMENT OF A LIQUID CRYSTAL DISPLAY FOR PLANS

by

Marc Dion
Electromagnetic Section
Electronics Division

DEFENCE RESEARCH ESTABLISHMENT OTTAWA
TECHNICAL NOTE 88-16

PCN
32G44

June 1988
Ottawa

ABSTRACT

A Liquid Crystal Display (LCD) was designed as part of a Primary Land Arctic Navigation System (PLANS). It provides a convenient interface between the PLANS navigation system and the commander and driver of the vehicle. This document provides a general description of the displays and the operating instructions.

RÉSUMÉ

Un module d'affichage à cristaux liquides destiné à être intégré dans un système principal de navigation terrestre dans l'Artique (Primary Land Artic Navigation System (PLANS)) conçu par le CRDO a été réalisé pour permettre une communication facile entre le système PLANS et le commandant et le conducteur du véhicule. Le présent document donne une description générale du module et fournit les instructions nécessaires pour son installation et son opération.

TABLE OF CONTENTS

		PAGE
ABSTRACT/RÉSUMÉ	.....	iii
TABLE OF CONTENTS	.....	v
1.0 GENERAL INFORMATION	.....	1
1.1 FEATURES	.....	1
1.2 GENERAL DESCRIPTION	.....	1
1.3 CONVENTIONS	.....	2
1.4 RELATED DOCUMENTATION	.....	2
2.0 OPERATING INSTRUCTION	.....	3
2.1 DATA TRANSMISSION	.....	3
2.2 DISPLAY SELECTION	.....	4
2.3 INITIALISATION PROCEDURE	.....	4
2.4 WRITE OPERATION	.....	5
3.0 FUNCTIONAL DESCRIPTION	.....	13
3.1 GENERAL DESCRIPTION	.....	13
3.2 POWER SUPPLIES	.....	13
3.3 LINE RECEIVERS/DRIVERS	.....	13
3.4 CONTROL LOCIC	.....	13
3.5 TTL-TO-CMOS DRIVERS	.....	14
3.6 LCD PANEL DRIVERS	.....	14
3.7 LCD PANELS	.....	15
3.8 RESET	.....	15
3.9 BACKLIGHTING	.....	15
4.0 SUPPORT INFORMATION	.....	20
4.1 CONNECTOR SIGNAL DESCRIPTIONS	.....	20
4.2 PARTS LIST	.....	20
4.3 DIAGRAMS	.....	20

TABLES

TABLE 2-1 SERIAL TRANSMISSION AC CHARACTERISTICS 7
TABLE 2-2 SERIAL TRANSMISSION DC CHARACTERISTICS 7
TABLE 2-3 LCD SELECTION BYTE DESCRIPTION 8
TABLE 2-4 LCD DIGITS SEGMENT PATTERNS 12
TABLE 3-1 μPD7225 COMMANDS 16
TABLE 4-1 CONNECTOR PIN ASSIGNMENTS 21
TABLE 4-2 LCD MODULE PARTS LIST 22
TABLE 4-3 LCD DISPLAY PIN CONNECTIONS 24

FIGURES

FIGURE 2-1 WRITE CYCLE TIMING DIAGRAM 9
FIGURE 2-2 LCD DISPLAY BIT MAPPING 11
FIGURE 2-3 LCD DIGIT BIT MAPPING 12
FIGURE 3-1 LCD MODULE BLOCK DIAGRAM 17
FIGURE 3-2 μPD7225 BLOCK DIAGRAM 18
FIGURE 3-3 DISPLAY RAM CONFIGURATION 19
FIGURE 4-1 LCD PANEL LAYOUT 26
FIGURE 4-2 EL-LAMP LAYOUT 27
FIGURE 4-3 LCD MODULE SCHEMATIC DIAGRAM 28

1.0 GENERAL INFORMATION

This document provides general information, operating instructions and a functional description of a small Liquid Crystal Display Module (referred to as the remote display throughout this document) developed at DREO. This display was specifically designed to be incorporated into the PLANS navigation system. Each system includes two of this display. PLANS is an acronym for Primary Land Arctic Navigation System. PLANS is a low cost, microprocessor-based, integrated navigation system developed at DREO to meet the Arctic land navigation requirements for armoured personnel carriers (APC's). It is built around the Motorola 68000 microprocessor and uses VME and I/O Channel busses.

1.1 FEATURES

Features of the LCD display are listed below.

- Each display is interfaced through six lines only to allow easy remote installation: a single power supply (+12V), the ground and four signal lines.
- The display has a built-in heater to maintain proper operation at lower temperatures.
- The display is well visible in bright and dim light conditions. Each display includes its backlighting.
- Each display is complete with LCD panel and drivers, backlighting and serial communication interface.
- The display interfaces directly with the General Purpose Interface Module.

1.2 GENERAL DESCRIPTION

PLANS is a land vehicle mounted, optimally integrated, multisensor navigation system employing Kalman filtering to provide optimal estimates of the vehicle position, speed and heading. Each PLANS navigation system includes a main display and two identical remote LCD displays. The main display, which is not covered by this document, and its associated keypad are the primary interface between the operator and the PLANS system. The two small remote displays are used by the commander and the driver of the vehicle. They continuously display the latitude and longitude, the current heading, the desired heading or the delta heading. They also display the delta heading in the form of a bow-tie graph.

Both remote LCD displays are identical. One is used by the driver and the other by the commander of the vehicle. Both are contained in a small package, which are remotely located, complete with an LCD panel, back-lighting, controller and LCD drivers. The LCD panel was specially designed to meet the PLANS requirements and was manufactured by Data Images of Ottawa. It has a viewing area of 3.8 cm by 9.7 cm.

The data is sent to all displays through a common serial link. Each display has the necessary logic to demultiplex the data received and to control the LCD drivers.

1.3 CONVENTIONS

Unless otherwise specified, all numbers preceded by "$" are in hexadecimal throughout this document.

Signal names which are overscored or followed by an asterisk (*) for signals which are level significant denotes that the signal is true or valid when the signal is low.

Signal names which are overscored or followed by an asterisk (*) for signals which are edge significant denotes that the actions initiated by that signal occur on a high to low transition.

1.4 RELATED DOCUMENTATION

- Development of a General Purpose Interface Module for PLANS (DREO Technical Note No, 86/21).
- μPD7225 Intelligent Alphanumeric LCD Controller Driver Technical Manual.

2.0 OPERATING INSTRUCTIONS

This chapter provides the necessary information to initialise and operate the remote LCD Display in a typical system configuration.

The PLANS navigation system uses a Motorola 68000 microprocessor which includes a ROM-based operating system (VRTX/X). The operating system and the application tasks (data collection, navigation functions, Kalman filter, etc.) reside in ROM. The operating system manages the system resources, such as the CPU, the memory and the sensors. VRTX/X is a real-time, interrupt-driven operating system which features multitasking support, intertask communication and synchronisation, dynamic memory allocation and provides high-level I/O functions to the various devices or sensors through device drivers. An I/O device driver is an asynchronous routine called by the executive to service an I/O device and handle all its device-specific operations (low-level I/O). It is also responsible for the proper initialisation of the device.

Section 2.1 describes the electrical conventions to transmit to the LCD display. DREO Technical Note #86/21 describes the module designed at DREO to interface with the LCD displays. Sections 2.2 to 2.4 describe the programming conventions required to implement the low-level functions of an I/O driver. More details about the programming are found in the related documentation.

2.1 DATA TRANSMISSION

All the displays share the same power and data lines. A single transmitter will broadcast command or data to all displays along with some addressing information. The data is sent by using three output lines: a selection output line (SELECT*), a serial data output line (TDAT*) and a serial clock output line (TCLK*). A fourth line (BUSY*), connected in a wire-ored configuration, provides the necessary handshaking. Each LCD display has its own serial interface controller which performs the necessary address decoding and sends the data to the appropriate driver.

The data is sent to all the LCD displays simultaneously as a series of bytes. Those bytes fall into three different categories: selection, command and data bytes. A selection byte determines which one(s) of the drivers is selected, and in which mode (command or data mode). The command bytes consist of one or more commands to be executed by the selected driver(s), such as "set cursor", "reset", etc. The data bytes contain the data to be displayed by the selected driver(s) and consists of pure binary data. Each bit corresponds to a pixel (one segment or one dot) on the display.

Prior to sending a byte, the SELECT* input should be asserted if a selection byte follows or negated for a command/data byte. When the BUSY* output is negated, an 8-bit byte can be clocked through the TDAT* input in synchronisation with the rising edge of TCLK* starting with the most significant bit. Since the data is transferred one bit at a time, eight TCLK* pulses are required to complete the input of a byte. BUSY* is then asserted, prohibiting further input to the display. Note that SELECT* should be held constant while a byte is being sent and that all eight pulses of TCLK* should be transmitted. Table 2-1 and Figures 2-1 show the timing diagram for the serial data transmission. Table 2-2 gives the DC characteristics of the signal lines.

2.2 DISPLAY SELECTION

Before any command or data can be sent, it is necessary to select a particular driver and specify the mode by sending a selection byte. It is achieved by asserting SELECT* and sending a byte, corresponding to a mask. The bit 7 of that byte controls whether a stream of command (bit set) or data (bit cleared) bytes will follow. Bits 0-3 select one or more of the drivers on the main display, bits 4-6 select one of the drivers on the remote displays. The bits 0-6 are active low, therefore the corresponding driver is selected when the bit is cleared. Table 2-3 shows which driver on which display is selected by the bits 0-6. The selected drivers remain selected in the mode specified (command or data) until explicitly deselected or until an other selection byte is sent. After one or more drivers have been selected, command or data bytes can then be sent to those drivers. It is achieved by first negating SELECT*, and then sending the stream of bytes through TDAT* and TCLK*. The mode is specified by the bit 7 of the previous selection byte. When none of the drivers is currently accessed, all the drivers should be left deselected by writing the selection byte "$FF".

In addition to the software display selection described above, each LCD module has two "bottom half" areas defined. A toggle switch allows the user to select either one.

2.3 INITIALISATION PROCEDURE

Upon power-up, the serial interface and LCD drivers must be properly initialised. The serial interface is initialised by sending the byte "$FF" with SELECT* negated. The remote LCD display panels are driven by two μPD7225 drivers each. Each LCD driver must be initialised by sending a stream of commands. A selection byte must be sent first, selecting one or more drivers and specifying command mode (bit 7 set), followed by the command

bytes.

Both drivers on the remote displays are initialised in the same configuration. A "Mode Set" command must specify 4-backplane operation, three voltage levels and the frequency set to "f_0+2^7" (command= $40). The commands "Unsynchronous Data Transfer" ($31), "Disable Segment Decoder" ($14), "Clear Blinking RAM" ($00) and "Disable Blinking" ($18) should also be sent. Upon power-on, the display RAM is unspecified. The command "Clear Display RAM" ($20) resets all bits of the display RAM. Finally, the "Enable Display" command ($11) turns on the LCD timing.

Refer to the μPD7225 LCD Controller/Driver Technical Manual for more information about the programming of the drivers.

2.4 WRITE OPERATION

After all the drivers have been properly initialised, the LCD displays are ready to receive further commands or data.

Each LCD driver contains a 32 x 4 bit RAM which stores the LCD data and a data pointer which is used to address the RAM. After a particular driver is selected, the data pointer may be loaded with an even address to point a specific digit or picture element with a "LOAD DATA POINTER" command. One or more bytes of data can then be sent. Each byte loads two consecutive locations (nibbles) into the RAM and forms one digit. The data pointer is automatically incremented to point to the next RAM location (ie. the next digit). When the transmission of data is completed, the driver is deselected which causes the LCD display to be refreshed with the new data.

The Figure 2-2 shows the correspondence between each RAM location and the individual digit or picture element of the LCD display. It lists the address of each digit and the "address/bit #" of the picture elements. A bit set to 1 makes the corresponding segment on the display visible. Figure 2-3 and Table 2-4 list the appropriate bit pattern to display the ten numeric characters. Note that bit 7 controls the decimal point (".") or the colon (":") if any.

Figure 2-1 (sheet 2) is an example of data transmission. It shows how to display the digits "12" in the minutes field of the latitude. A stream of 6 bytes is sent to the display, which selects the appropriate driver, loads the data pointer, sends the actual data and finally deselects the driver. The first byte ("$EF") selects the driver controlling the top half of the display in command mode. The appropriate code is taken from Table 2-3. The second byte ("$F6") corresponds to the "LOAD DATA POINTER" command. It sets the data pointer to "22" to point to the desired digit as seen in Figure 2-2. The third byte ("$6F")

puts the selected driver in data mode. The next two bytes ("$60" and "$BE") are the bit patterns corresponding to the digits "1" and "2" as listed in Table 2-4. Note that bit 7 of the second data byte is set to display the decimal point. The last byte ("$FF") deselects the driver and that completes the transmission.

TABLE 2-1. Serial Transmission AC Characteristics

NUMBER	DESCRIPTION	MIN	TYP	MAX	UNIT
1	TCLK* pulse width high		40		μsec
2	TCLK* pulse width low		40		μsec
3	TCLK* hold time after BUSY* ↑	0			nsec
4	TDAT* setup time to TCLK* ↑	100			nsec
5	TDAT* hold time to TCLK* ↑	250			nsec
6	BUSY* delay after 8th TCLK* ↑			3	μsec

TABLE 2-2. Serial Transmission DC Characteristics

PARAMETER	MIN	TYP	MAX	UNIT
Logic "1" input voltage	-3		-25	V
Logic "0" input voltage	+3		+25	V
Input impedance	3		7	kΩ
Logic "0" output voltage			+1	V
Logic "1" output voltage	+10			V

TABLE 2-3. LCD Selection Byte Description

BIT #	DESCRIPTION
0	Select the main display: - bottom left
1	- bottom right
2	- top left
3	- top right
4	Select the remote displays: - top half
5	- bottom half, part 1
6	- bottom half, part 2
7	Specify command or data mode.

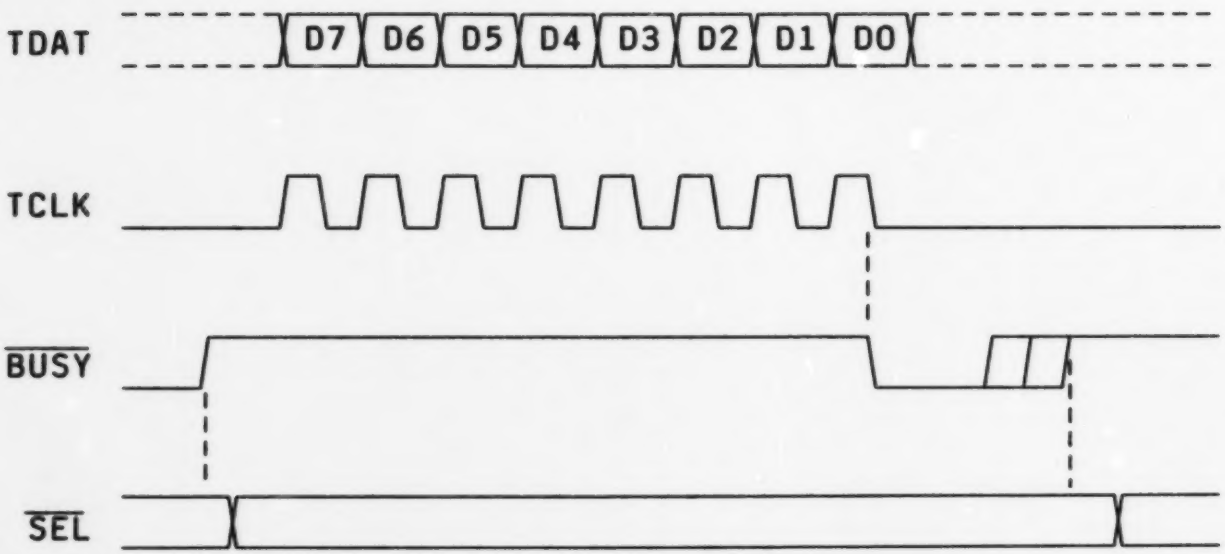

FIGURE 2-1. Write Cycle Timing Diagram (sheet 1 of 2)

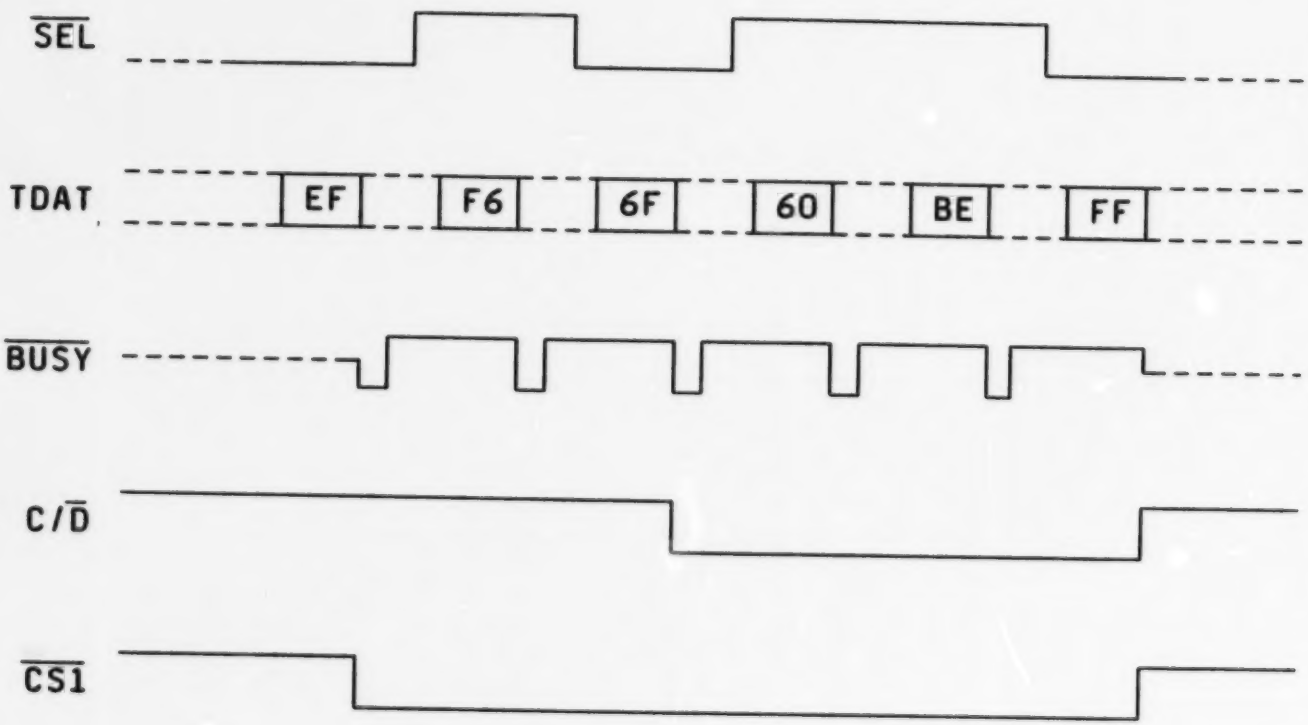

FIGURE 2-1. Write Cycle Timing Diagram (sheet 2 of 2)

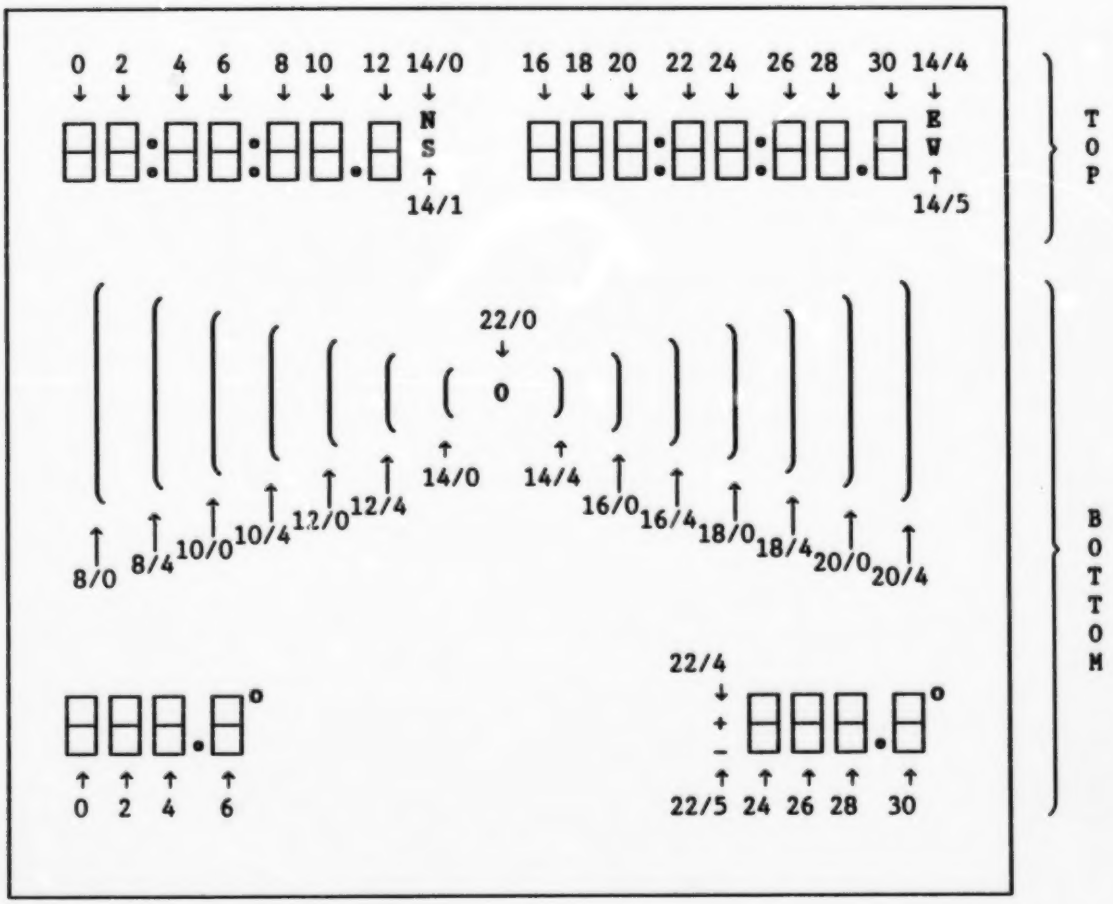

FIGURE 2-2. LCD Display Bit Mapping

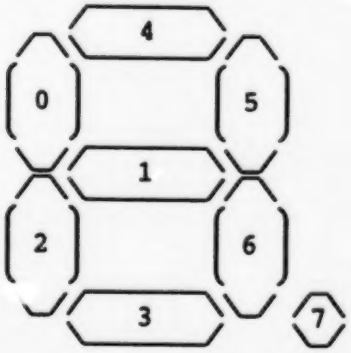

FIGURE 2-3. LCD Digit Bit Mapping

TABLE 2-4. LCD Digits Segment Patterns

DIGIT	CODE
"0"	$7D
"1"	$60
"2"	$3E
"3"	$7A
"4"	$63
"5"	$5B
"6"	$5F
"7"	$70
"8"	$7F
"9"	$7B

3.0 FUNCTIONAL DESCRIPTION

This chapter describes the overall block diagram for the remote LCD display module, followed by a detailed description of each section.

3.1 GENERAL DESCRIPTION

The LCD module processes incoming serial data to be displayed onto an LCD panel. It includes the necessary control logic to perform the required addressing and data dispatching. It incorporates intelligent peripheral devices to perform some data manipulations and generate the complex waveforms to drive the LCD panels.

Figure 3-1 shows a block diagram of the LCD module. The signals are first translated to TTL levels. The data (TDAT* and TCLK*) is intercepted by the control logic which will be used for control and addressing functions or sent to the LCD drivers, depending on the state of the SELECT* line. The LCD drivers contain all the necessary circuitry to drive the LCD panels.

3.2 POWER SUPPLIES

Although the displays are supplied with only one voltage (+12V), the logic board and the drivers require a +5V supply. This voltage is obtained from the +12V through a voltage regulator (such as #LM317) in a standard configuration.

3.3 LINE RECEIVERS/DRIVERS

The input signals (TCLK*, TDAT* and SELECT*) are RS-232C levels. A line MC1489 receiver is used to convert those input to a TTL level. An external capacitor is used to limit the bandwidth and improve the noise rejection.

The output BUSY* is a simple two-transistor driver that converts the low current open-drain BUSY* output of the LCD drivers to a 0-12 volt output.

3.4 CONTROL LOGIC

The main purpose of the logic board is to catch the selection bytes and use them to select the appropriate LCD driver(s) and specify the mode (command or data). It also supplies the LCD drivers with a free-running clock and passes the

TCLK* and TDAT* signals when necessary. The outputs of the logic board to the drivers are CS1*, CS2*, SCK*, SI*, C/D* and CL1.

When SELECT* is negated, the TCLK* and TDAT* inputs are passed directly to the SCK* and SI* inputs of the LCD drivers. When SELECT* is asserted, the TCLK* input is not sent to the SCK* input of the LCD drivers, preventing them from interpreting the data coming on TDAT*. The 8 data bits from TDAT* are shifted into a serial-to-parallel register (U1) by using TCLK* to synchronise. After the 7th pulse on TCLK*, the CO output of U2 is asserted, enabling the parallel output of U1 to be latched by U3 on the 8th pulse. The outputs of the latched are the "chip select" (CS1* and CS2) and the command/data line (C/D*) to the LCD drivers.

3.5 TTL-TO-CMOS DRIVERS

The logic board uses TTL logic and the LCD drivers use CMOS logic. The logic board outputs several signals to the LCD drivers (SCK*, SI*, CS*, C/D* and CL1). Those signals are all TTL level and they must be converted to CMOS level. The LCD drivers are supplied with 5 volt, so a simple pull-up resistor performs the conversion.

3.6 LCD PANEL DRIVERS

Two μPD7225 controller/drivers are use to drive the remote LCD panel. It is an intelligent peripheral device designed to interface microprocessors with a wide variety of alphanumeric LCDs. Figure 3-2 shows the block diagram of the μPD7225. It is equipped with several hardware logic blocks, such as an 8-bit serial interface, an ASCII character generator, a static RAM for pixel data storage, blinking capability and an LCD timing controller, all of which reduce microprocessor system software requirements. Because the LCD panels don't have a standard segment configuration, the on-chip character generator cannot be used. The Display RAM is a static RAM which stores LCD data. There is a 1-to-1 correspondence between the RAM addresses and the segment drives, and between the individual RAM bits and the backplane drives. The Data Pointer is a register which addresses locations in the Display RAM. The Data Pointer is reset to zero when a driver is selected (CS* goes low). Whenever data is serially transferred into the Display RAM (C/D* is low), the Data Pointer is automatically increased to point to the next location.

The μPD7225 can directly drive any static or multiplexed LCD containing up to four backplanes and up to 32 segments and is easily cascaded for larger LCD applications. The top and bottom part of the remote LCD panels are wired independently and are driven by one μPD7225 each. Therefore, each μPD7225 is wired in

a single-chip configuration. Figure 3-3 shows the correspondence between the Display RAM and the segments. The Display RAM is a static 32 x 4 bit RAM. The Data Pointer is a 5-bit register which simultaneously addresses the same locations in the Display RAM and the Blinking RAM. Whenever a data byte is transferred into the Display RAM, two consecutive RAM locations are updated and the Data Pointer is automatically increased by 2. The Data Pointer automatically wraps around through address 0. Table 3-1 lists the most commonly used commands of the μPD7225.

3.7 LCD PANELS

The LCD panels were specially designed by Data Images Inc. to meet the PLANS requirements. They are optimised to provide good contrast when viewed from 0° (front) to 60° (top). They incorporate a transparent thin film to heat the panel and to extend the operational temperature range. The panel can be lighted from the front (ambient light) or from the back (EL-lamp). Figure 4-1 shows the layout of the LCD panels.

3.8 RESET

Upon power-up, a simple R-C network with a time constant of ~5 msec provides the hardware reset for the LCD drivers. The drivers must then be properly initialised by software. The serial communication interface must be initialised by software, by sending the byte "$FF" with SELECT* negated.

3.9 BACKLIGHTING

Backlighting of the LCD panels is achieved by using an electroluminescent lamp (EL-lamp). EL-lamps are cold light sources, operating over a wide range of temperature. EL-lamps are thin and flexible and are mounted right behind the LCD panels, providing a uniform source of illumination. They were custom fabricated to fit the LCD panels. The EL-lamps are 1.6" x 4.0" with a lit area of 1.44" x 3.75". They produce a green light.

EL-lamps operate from a high voltage AC power source, typically 90-100 volt AC at 400-700 cycles. A DC-to-AC converter (#LPS-12-1-4) is used for each EL-lamp which converts the 12 Vdc to the nominal AC voltage. The EL-lamp can be easily dimmed by the use of a simple potentiometer.

TABLE 3-1. μPD7225 Commands

COMMAND	DESCRIPTION	COMMAND CODE
Mode Set	Initialise the μPD7225 and set frequency to "f_o+2^7"	01000000
Unsynchronous Data Transfer	Sync data transfer with CS*	00110001
Load Data Pointer	Load Data Pointer with 5 bits of immediate data	111XXXXX
Clear Display RAM	Clear the Display RAM and reset the Data Pointer	00200000
Disable Blinking	Stop segment blinking	00011000
Disable Segment Decoder	Stop use the segment decoder	00010100
Enable Display	Turn on the LCD	00010001

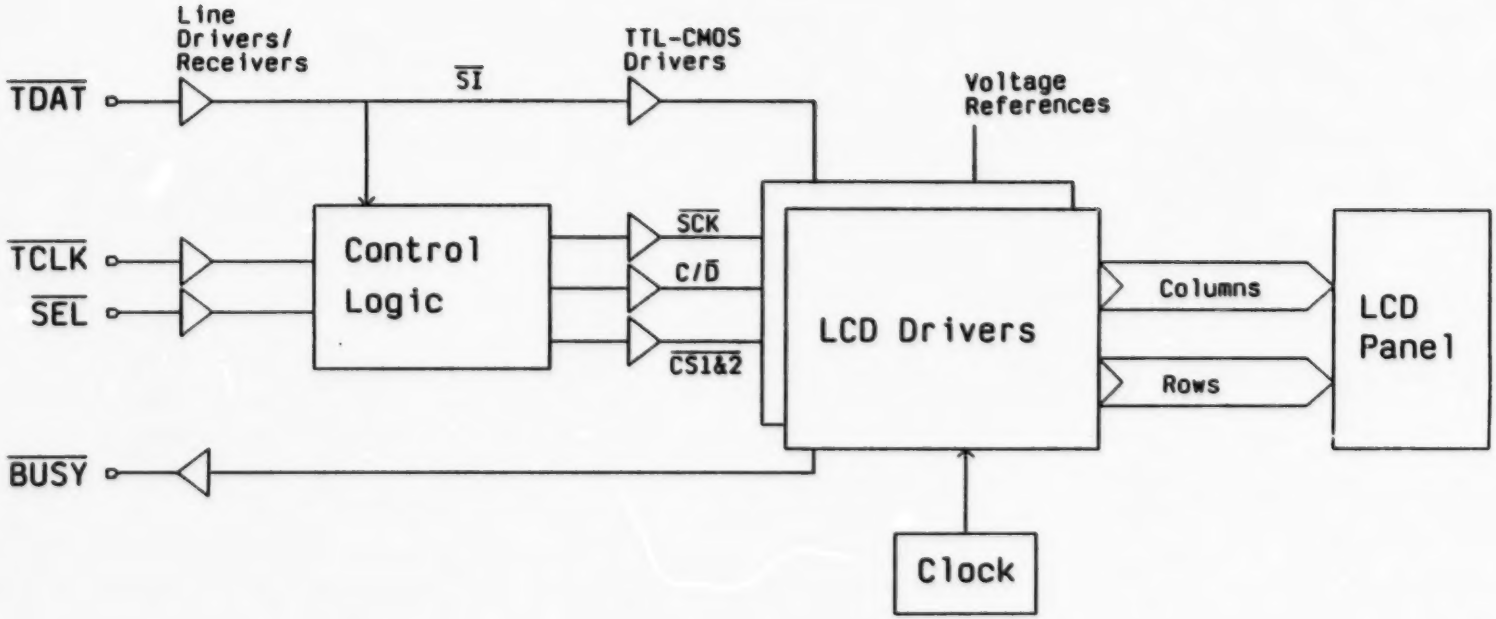

FIGURE 3-1. LCD Module Block Diagram

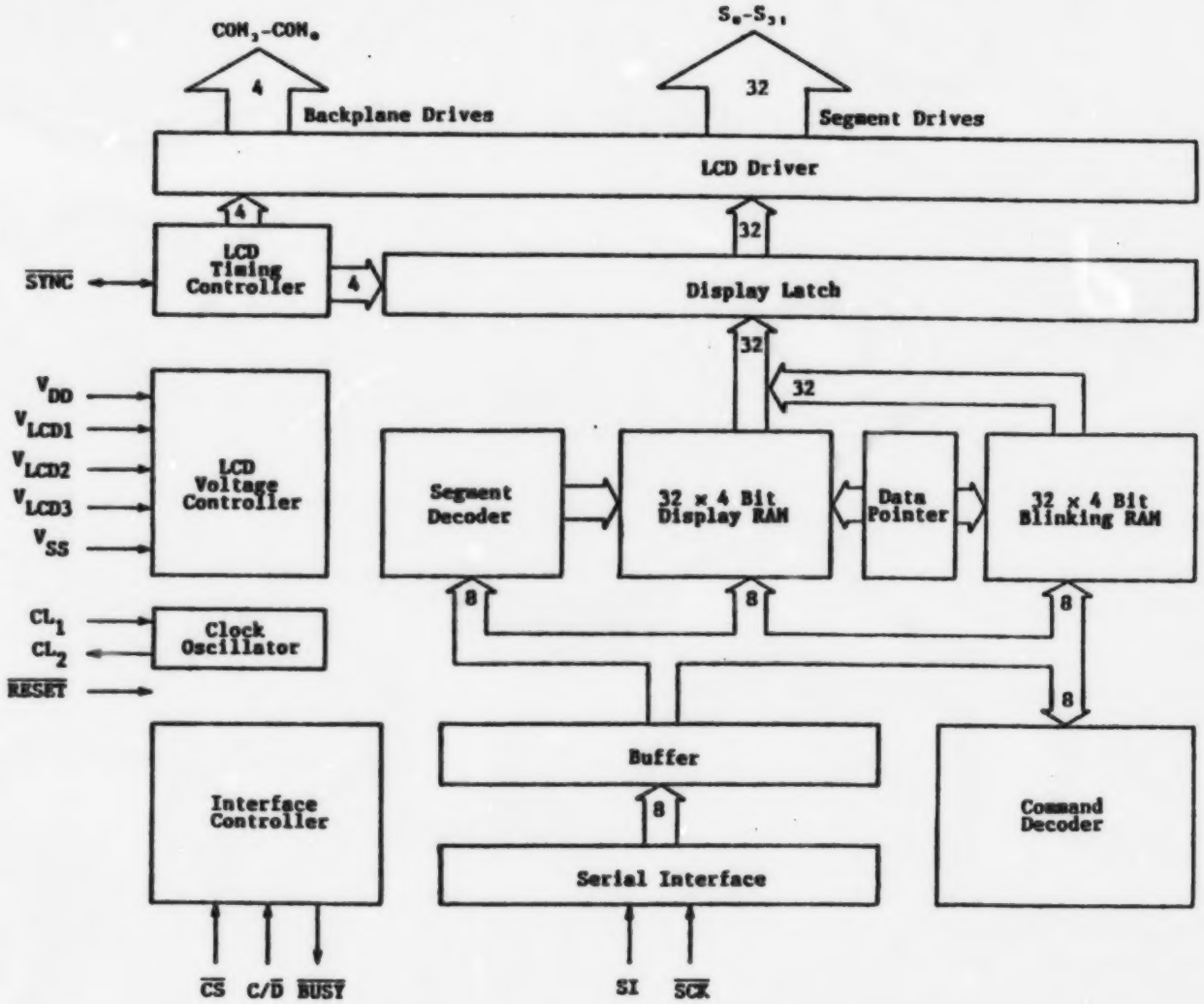

FIGURE 3-2. μPD7225 Block Diagram

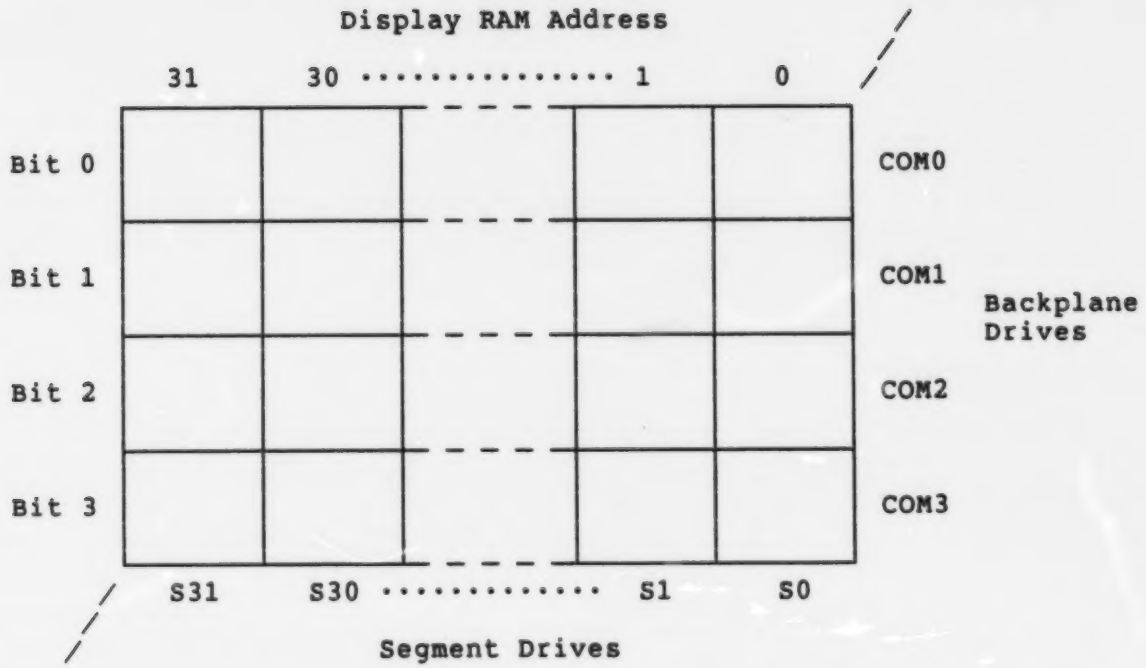

FIGURE 3-3. Display RAM Configuration

4.0 SUPPORT INFORMATION

This chapter provides the connector signal descriptions, parts list and associated parts location diagram and the schematic diagrams for the LCD displays.

4.1 CONNECTOR SIGNAL DESCRIPTIONS

A connector is mounted on the side of the remote display providing the only connection necessary to use it with the PLANS system. Table 4-1 lists the pin assignments.

4.2 PARTS LIST

Table 4-2 lists the components of the LCD displays. The device type number in this table is for reference only. The number varies with the manufacturer.

4.3 DIAGRAMS

Figure 4-3 shows the schematic diagrams for the remote display. Connections between the drivers and the LCD panels are not shown on the schematic diagrams but are listed separately in Table 4-3.

TABLE 4-1. Connector Pin Assignments

SIGNAL MNEMONIC	SIGNAL NAME AND DESCRIPTION
GND	GROUND
+12V	+12 Vdc power, ±10%
SELECT*	DISPLAY SELECT - Input signal used to differentiate between selection bytes and command/data bytes.
BUSY*	BUSY - Output signal used to synchronise the LCD transmitter and receivers.
TCLK*	SERIAL CLOCK - Input signal used to clock the serial data on TDAT*.
TDAT*	SERIAL DATA - Serial data input to the displays.

TABLE 4-2. LCD Module Parts List

REFERENCE DESIGNATION	DESCRIPTION
C1,C10-C12	Capacitor, 0.001μF
C2,C6-C8,C13-C18	Capacitor, 0.01μF
C3	Capacitor, 2.2μF
C4	Capacitor, 0.1μF
C5	Capacitor, 1.0μF
C9	Capacitor, 0.047μF
EL1	Custom made EL-lamp Luminescent System Inc, #X6330-1232
LCD1	Custom made LCD display Data Images Inc.
R1,R2,R3	Resistor, 10kΩ
R4-R8	Resistor, 1.5kΩ
R9-R11	Resistor, 5.1kΩ
R12	Resistor, 15kΩ
R13-R14	Resistor, 3.9kΩ
R15	Resistor, 240Ω
R16	Potentiometer, 1kΩ, 25 turns
R17-R20	Resistor, 1kΩ
R21	Resistor, 100kΩ
Q1	NPN transistor, 2N3904
Q2	PNP transistor, 2N3906

TABLE 4-2. LCD Module Parts List (cont'd)

REFERENCE DESIGNATION	DESCRIPTION
U1	I.C. 74LS164
U2, U3	I.C. 74LS163
U4	I.C. MC1489
U5	I.C. 74LS00
U6	I.C. LM555
U10-U11	I.C. NEC μPD7225, LCD Controller/Driver
VR1	Voltage regulator, LM317T
VR2	DC-to-AC converter Endicott Research Group, #LPS-12-1-4

TABLE 4-3. LCD Displays Pin Connections

DISPLAY PIN #	IC AND PIN #	FUNCTION
1	U11 17	COM2
2	U11 15	COM0
3	U11 19	S0
4	U11 20	S1
5	U11 21	S2
6	U11 22	S3
7	U11 23	S4
8	U11 24	S5
9	U11 25	S6
10	U11 26	S7
11	U11 27	S8
12	U11 28	S9
13	U11 29	S10
14	U11 30	S11
15	U11 31	S12
16	U11 32	S13
17	U11 34	S14
18	U11 42	S22
19	U11 35	S15
20	U11 36	S16
21	U11 37	S17
22	U11 38	S18
23	U11 39	S19
24	U11 40	S20
25	U11 41	S21
26	U11 43	S23
27	U11 44	S24
28	U11 45	S25
29	U11 46	S26
30	U11 47	S27
31	U11 48	S28
32	U11 49	S29
33	U11 50	S30
34	U11 51	S31
35	U11 16	COM1
36	U11 18	COM3

TABLE 4-3. LCD Displays Pin Connections (cont'd)

DISPLAY PIN #	IC AND PIN #	FUNCTION
37	U10 16	COM1
38	U10 18	COM3
39	U10 35	S15
40	U10 51	S31
41	U10 50	S30
42	U10 49	S29
43	U10 48	S28
44	U10 47	S27
45	U10 46	S26
46	U10 45	S25
47	U10 44	S24
48	U10 43	S23
49	U10 42	S22
50	U10 41	S21
51	U10 40	S20
52	U10 39	S19
53	U10 38	S18
54	U10 37	S17
55	U10 36	S16
56	U10 34	S14
57	U10 32	S13
58	U10 31	S12
59	U10 30	S11
60	U10 29	S10
61	U10 28	S9
62	U10 27	S8
63	U10 26	S7
64	U10 25	S6
65	U10 24	S5
66	U10 23	S4
67	U10 22	S3
68	U10 21	S2
69	U10 20	S1
70	U10 19	S0
70	U10 17	COM2
72	U10 15	COM0

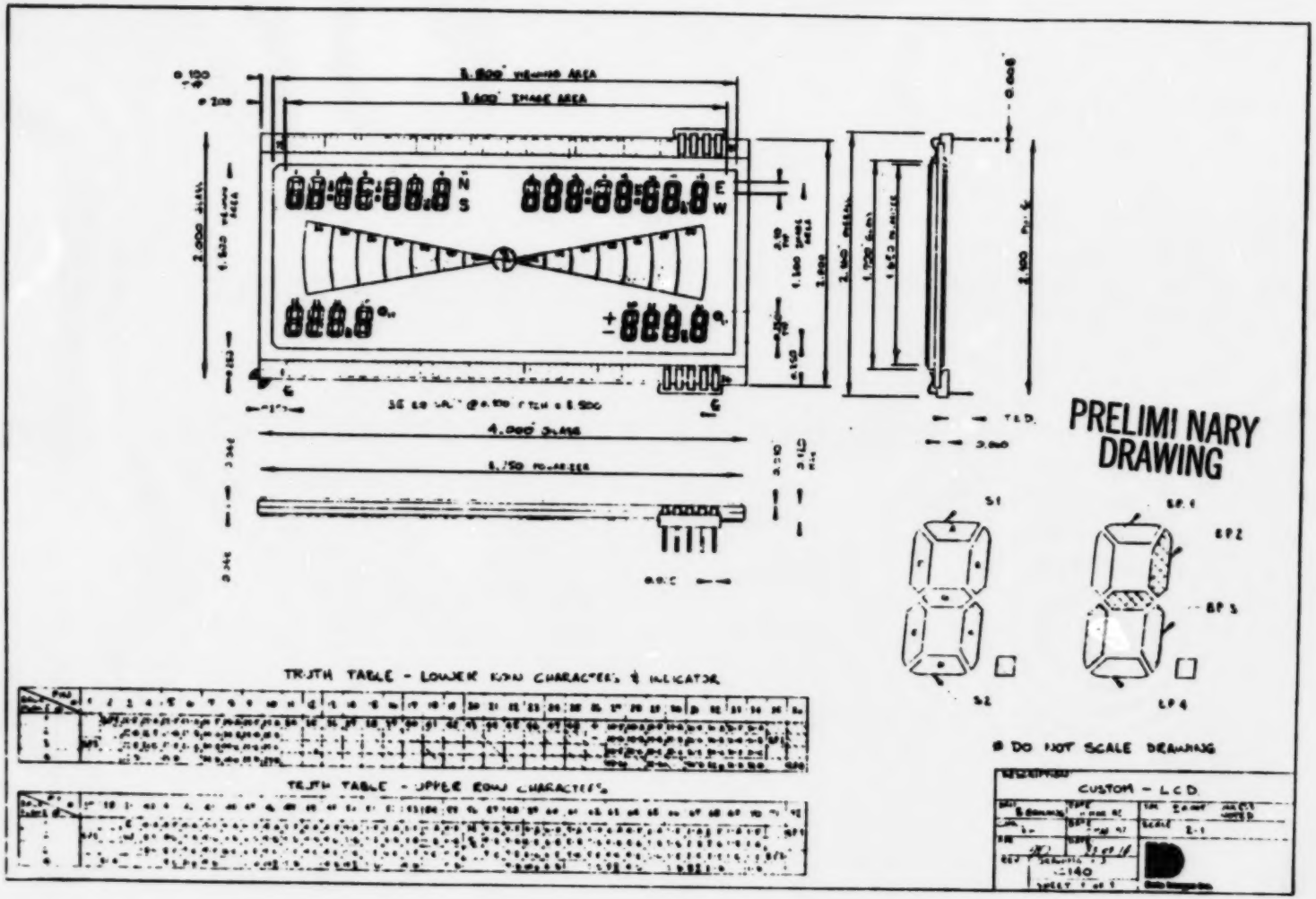
PRELIMI NARY
DRAWING
TRUTH TABLE - LOWER ROW CHARACTERS & INDICATOR
TRUTH TABLE - UPPER ROW CHARACTERS
DO NOT SCALE DRAWING
CUSTOM - LCD

FIGURE 4-1. LCD Panel Layout

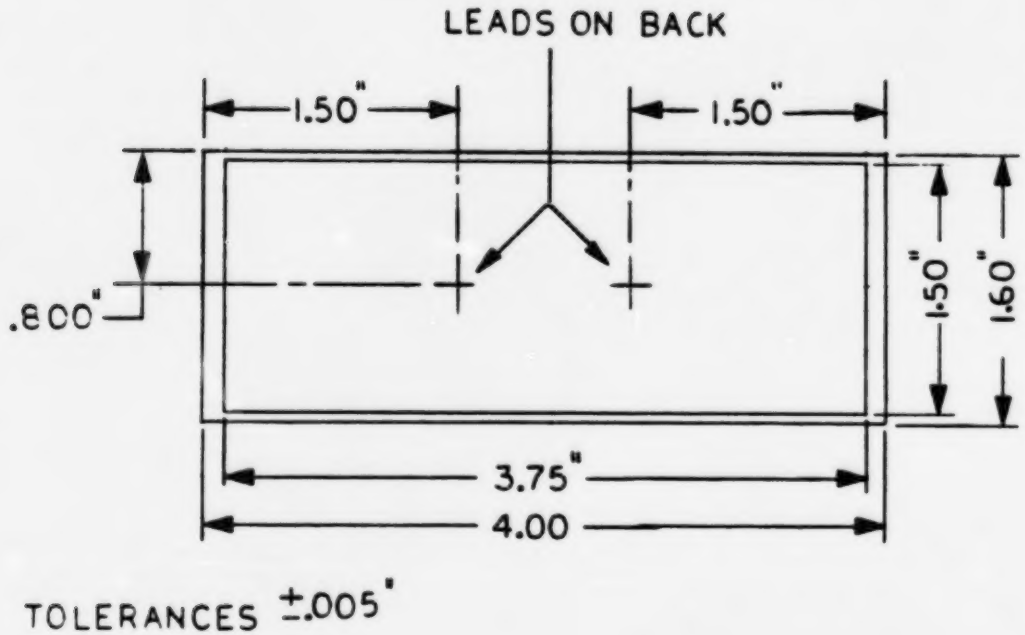

FIGURE 4-2. EL-Lamp Layout

REF	TYPE	GND	+5V
U1	74LS164	7	14
U2	74LS163	8	16
U3	74LS163	8	16
U4	MC1489	7	14
U5	74LS00	7	14
U6	LM555	1	8
U10	μPD7225	6	7,33
U11	μPD7225	6	7,33

HIGHEST NUMBER USED	NOT USED
C12	
EL1	
LCD1	
Q2	
R21	
U11	U7-U9
VR2	

NOTES:

1. Unless otherwise specified:
   All resistors are in Ohms, ±10%, 1/8 watt.
   All capacitors are in μF.
   All voltages are in DC.

2. Device type number in the table above is for reference only. The number varies with the manufacturer.

3. Part types are abbreviated in the field of the drawing. For full part type, refer to the table above.

Figure 4-3. LCD Module Schematic Diagram (Sheet 1 of 4)

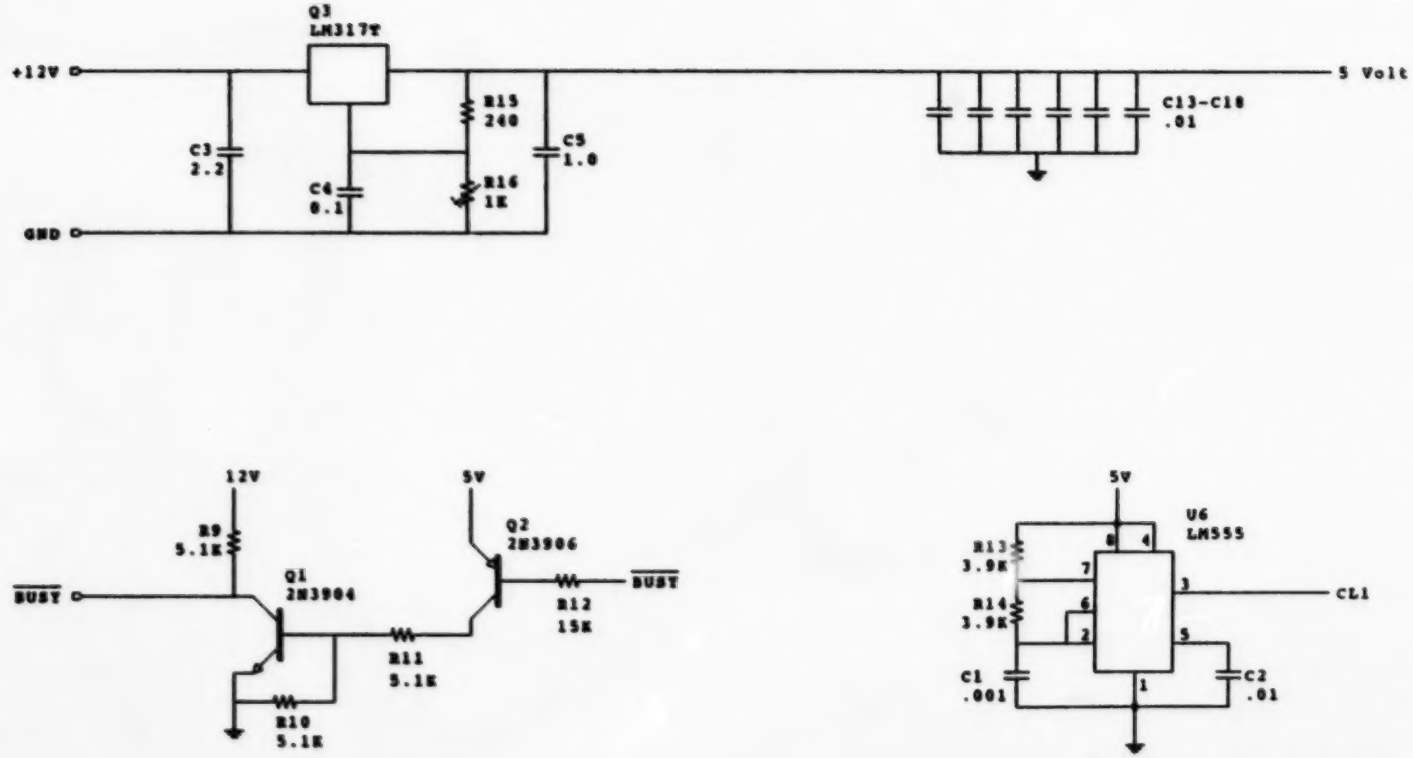

FIGURE 4-3. LCD Module Schematic Diagram (Sheet 2 of 4)

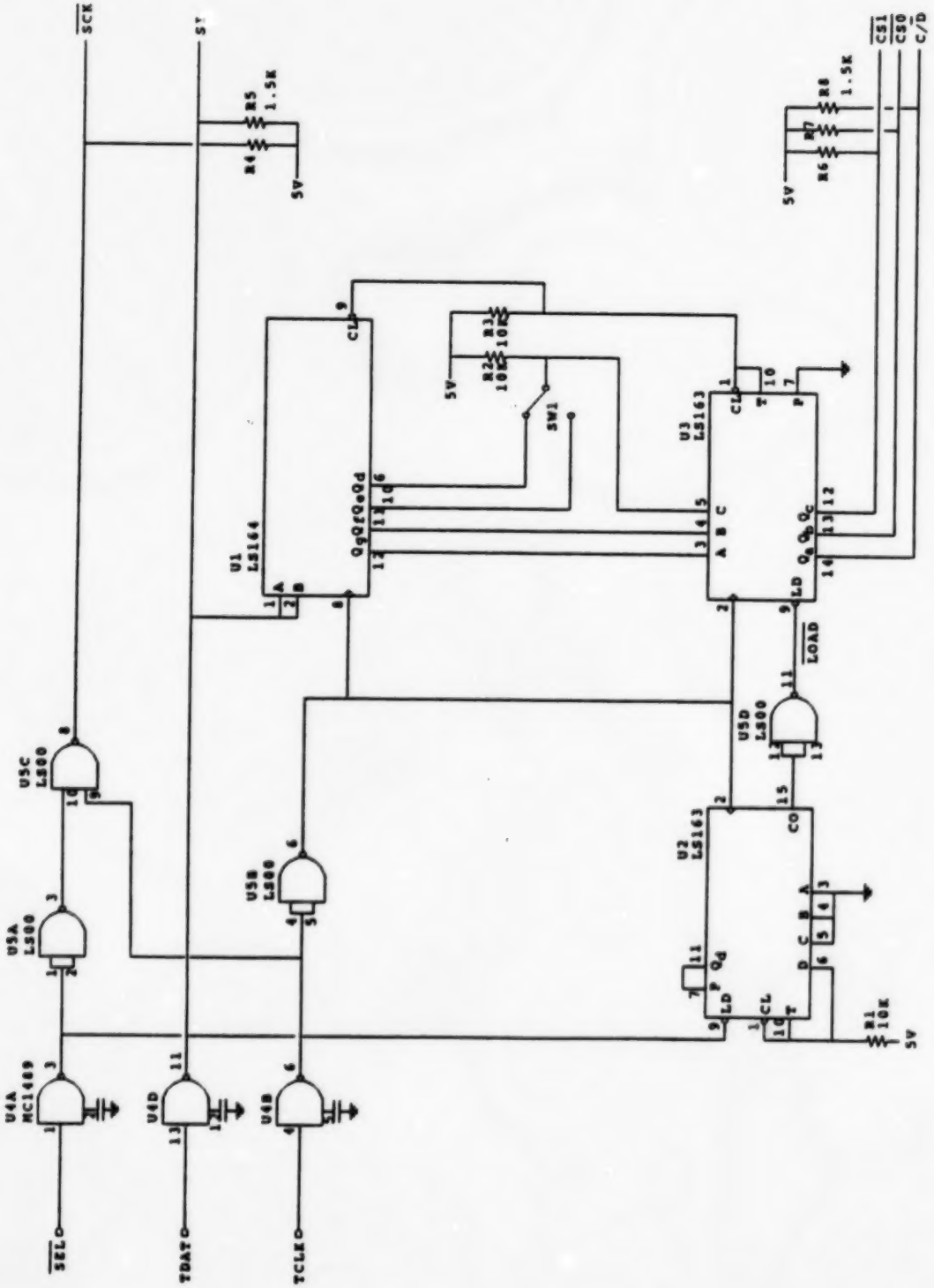

FIGURE 4-3. LCD Module Schematic Diagram (Sheet 3 of 4)

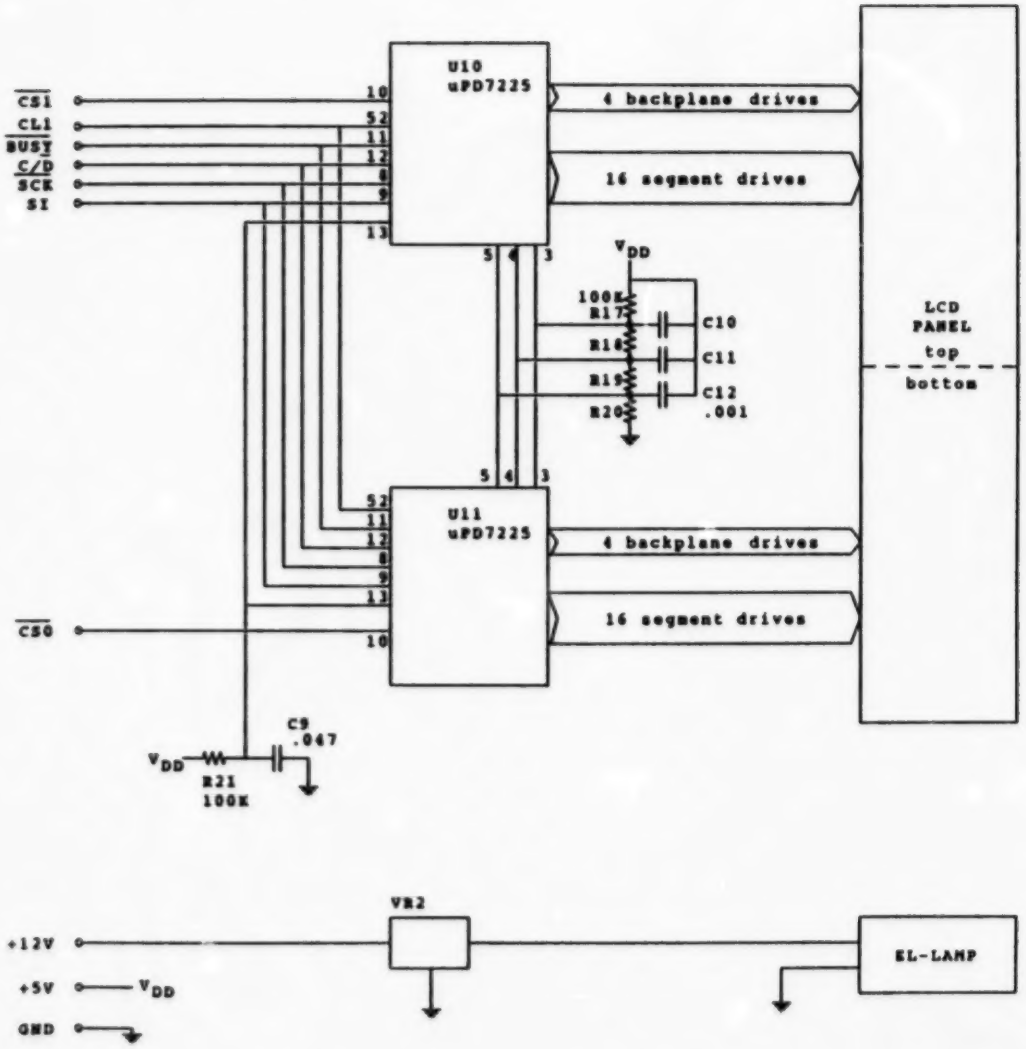

FIGURE 4-3. LCD Module Schematic Diagram (Sheet 4 of 4)

UNCLASSIFIED

SECURITY CLASSIFICATION OF FORM
(highest classification of Title, Abstract, Keywords)

DOCUMENT CONTROL DATA

(Security classification of title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATOR (the name and address of the organization preparing the document. Organizations for whom the document was prepared, e.g. Establishment sponsoring a contractor's report, or tasking agency, are entered in section 8.)

Defence Research Establishment Ottawa
National Defence Headquarters
Ottawa, Canada K1A 0Z4

2. SECURITY CLASSIFICATION (overall security classification of the document. including special warning terms if applicable)

UNCLASSIFIED

3. TITLE (the complete document title as indicated on the title page. Its classification should be indicated by the appropriate abbreviation (S,C,R or U) in parentheses after the title.)

Development of a Liquid Crystal Display for PLANS

4. AUTHORS (Last name, first name, middle initial)

Dion, Marc

5. DATE OF PUBLICATION (month and year of publication of document)

June 1988

6a. NO. OF PAGES (total containing information. Include Annexes, Appendices, etc.)

35

6b. NO. OF REFS (total cited in document)

2

7. DESCRIPTIVE NOTES (the category of the document, e.g. technical report, technical note or memorandum. If appropriate, enter the type of report, e.g. interim, progress, summary, annual or final. Give the inclusive dates when a specific reporting period is covered.)

Technical Note

8. SPONSORING ACTIVITY (the name of the department project office or laboratory sponsoring the research and development. Include the address.)

9a. PROJECT OR GRANT NO. (if appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant)

32G44

9b. CONTRACT NO. (if appropriate, the applicable number under which the document was written)

10a. ORIGINATOR'S DOCUMENT NUMBER (the official document number by which the document is identified by the originating activity. This number must be unique to this document.)

DREO Technical Note 88-16

10b. OTHER DOCUMENT NOS. (Any other numbers which may be assigned this document either by the originator or by the sponsor)

11. DOCUMENT AVAILABILITY (any limitations on further dissemination of the document, other than those imposed by security classification)

(X) Unlimited distribution
( ) Distribution limited to defence departments and defence contractors; further distribution only as approved
( ) Distribution limited to defence departments and Canadian defence contractors; further distribution only as approved
( ) Distribution limited to government departments and agencies; further distribution only as approved
( ) Distribution limited to defence departments; further distribution only as approved
( ) Other (please specify):

12. DOCUMENT ANNOUNCEMENT (any limitation to the bibliographic announcement of this document. This will normally correspond to the Document Availabilty (11). However, where further distribution (beyond the audience specified in 11) is possible, a wider announcement audience may be selected.)

UNCLASSIFIED

SECURITY CLASSIFICATION OF FORM

UNCLASSIFIED

SECURITY CLASSIFICATION OF FORM

13. ABSTRACT (a brief and factual summary of the document. It may also appear elsewhere in the body of the document itself. It is highly desirable that the abstract of classified documents be unclassified. Each paragraph of the abstract shall begin with an indication of the security classification of the information in the paragraph (unless the document itself is unclassified) represented as (S), (C), (R), or (U). It is not necessary to include here abstracts in both offical languages unless the text is bilingual).

A Liquid Crystal Display (LCD) was designed as part of a Primary Land Arctic Navigation System (PLANS). It provides a convenient interface between the PLANS navigation system and the commander and the driver of the vehicle. This document provides a general description of the displays and the operating instructions.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus. e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus-identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

PLANS
PRIMARY LAND ARCTIC NAVIGATION SYSTEM
NAVIGATION SYSTEM
DISPLAY
LCD DISPLAY
LIQUID CRYSTAL DISPLAY

SECURITY CLASSIFICATION OF FORM